STABILIZATION OF DOPANT CONCENTRATION IN SEMICONDUCTOR DEVICE HAVING EPITAXIALLY-FILLED TRENCH

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is based on and incorporates herein by reference Japanese Patent Application No. 2002-161594 filed on Jun. 3, 2002.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to a semiconductor device, in the manufacturing process of which a trench is filled with an epitaxially grown film, and a method for manufacturing the device.

[0003] The inventors of the present invention propose the following method, which is shown in **FIGS. 8A** to **8F**, for forming a trench in a semiconductor layer and filling the trench with an epitaxially grown film in U.S. Pat. No. 6,406,982 (JP-A-2002-124474). In the method, firstly, an n-type drift layer **120** is formed on an n^+-type substrate **110** to form a semiconductor substrate **132**, and a mask layer **131** is formed by patterning a film deposited on the substrate **132** using photolithography and etching, as shown in **FIG. 8A**.

[0004] Then, the n-type drift layer **120** is partially etched using the mask layer **131** in order to form trenches **111**, as shown in **FIG. 8B**. Then, the mask layer **131** is removed using hydrofluoric acid (HF) aqueous solution, as shown in **FIG. 8C**. Next, the substrate **132** is heated in non-oxidizing and non-nitridizing atmosphere in order to smooth the surfaces of the trenches **111** and in order to cure the crystallographic defects located in the surfaces, as shown in **FIG. 5D**. After that, an epitaxially grown film **133** is deposited to fill the trenches **111**, as shown in **FIG. 8E**. Finally, the epitaxially grown film **133** is planarized, as shown in **FIG. 8F**.

[0005] In the method of U.S. Pat. No. 6,406,982, as described, the substrate **132** is heated in the non-oxidizing and non-nitridizing atmosphere before the epitaxially grown film **133** is deposited. The heating enables the epitaxially grown film **133** to be deposited on the inner surfaces of the trenches **111**, which has been smoothed and the crystallographic defects in which have been cured. As a result, the crystallographic defects that otherwise would be generated in the epitaxially grown film **133** are prevented.

[0006] However, there is a problem in the method of U.S. Pat. No. 6,406,982 that the dopant concentration in the substrate **132** can fluctuate to deviate from the predetermined concentration because the dopants contained in the semiconductor substrate **132** out diffuse during the heating.

SUMMARY OF THE INVENTION

[0007] The present invention has been made in view of the above aspects with an object to prevent the dopant concentration in a semiconductor substrate having a trench from fluctuating when the substrate is heated in a non-oxidizing and non-nitridizing atmosphere before an epitaxially grown film is deposited to fill the trenches in order to control the dopant concentration at a predetermined level.

[0008] To achieve the above object, a method according to the present invention for manufacturing a semiconductor device includes; forming a trench in a predetermined layer of a semiconductor substrate; heating the substrate having the trench in a non-oxidizing and non-nitridizing atmosphere containing a dopant or a compound that includes the dopant in order to smooth the surfaces of the trench and to maintain the dopant concentration in the predetermined layer to be a predetermined concentration before the heating is treated; and forming an epitaxially grown film to fill the trench. The conductivity type of the dopant contained in the non-oxidizing and non-nitridizing atmosphere is the same as that of the dopant initially contained in the predetermined layer.

[0009] Another method according to the present invention for manufacturing a semiconductor device includes: forming a trench in a predetermined layer of a semiconductor substrate; heating the substrate having the trench in a non-oxidizing and non-nitridizing atmosphere containing a dopant or a compound that includes the dopant in order to smooth surfaces of the trench and to diffuse the dopant contained in the non-oxidizing and non-nitridizing atmosphere into the predetermined layer and partially increase a dopant concentration in the predetermined layer to be a predetermined concentration higher than that before the heating is treated; and forming an epitaxially grown film to fill the trench.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description made with reference to the accompanying drawings. In the drawings:

[0011] **FIG. 1** is a partial schematic plan view of a semiconductor device according to a first embodiment of the present invention;

[0012] **FIG. 2** is a schematic cross-sectional view of the device in **FIG. 1** taken along the line **11**-II;

[0013] **FIGS. 3A** to **3J** are schematic cross-sectional views showing the steps for manufacturing the device in **FIG. 1**;

[0014] **FIGS. 4A** to **4C** are schematic cross-sectional views for explaining the step of **FIG. 3E**;

[0015] **FIG. 5** is a partial schematic plan view of a semiconductor device according to a second embodiment;

[0016] **FIG. 6** is a schematic cross-sectional view of the device in **FIG. 5** taken along the line VI-VI;

[0017] **FIGS. 7A** to **7C** are schematic cross-sectional views showing the steps for manufacturing the device in **FIG. 5**; and

[0018] **FIGS. 8A** to **8F** are schematic cross-sectional views showing the steps for manufacturing a proposed semiconductor device;

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0019] The present invention will be described in detail with reference to various embodiments,

[0020] First Embodiment

[0021] **FIG. 1** is a plan view of a power MOSFET having a super junction structure according to a first embodiment of